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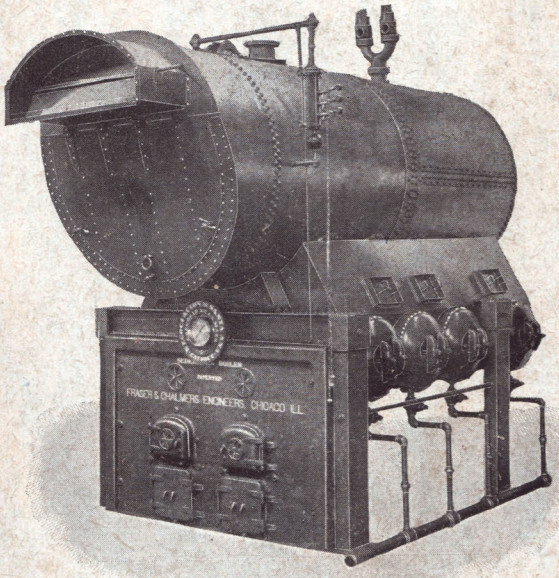
Catalogue No. 54

FRASER & CHALMERS

MANUFACTURERS OF THE

SEDERHOLM BOILERS

(PATENTED)



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SEDERHOLM BOILERS

FOR

High Pressures and Large Units

BUILT BY

FRASER & CHALMERS

CHICAGO, ILL., U. S. A.

1900

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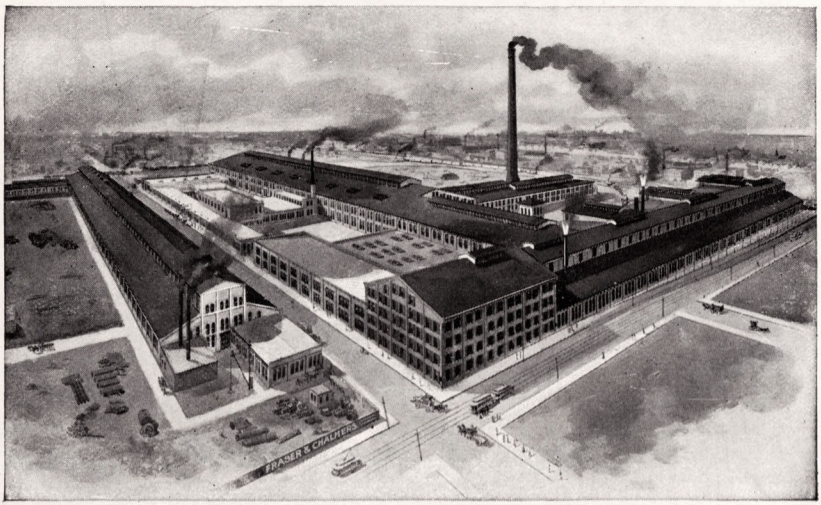

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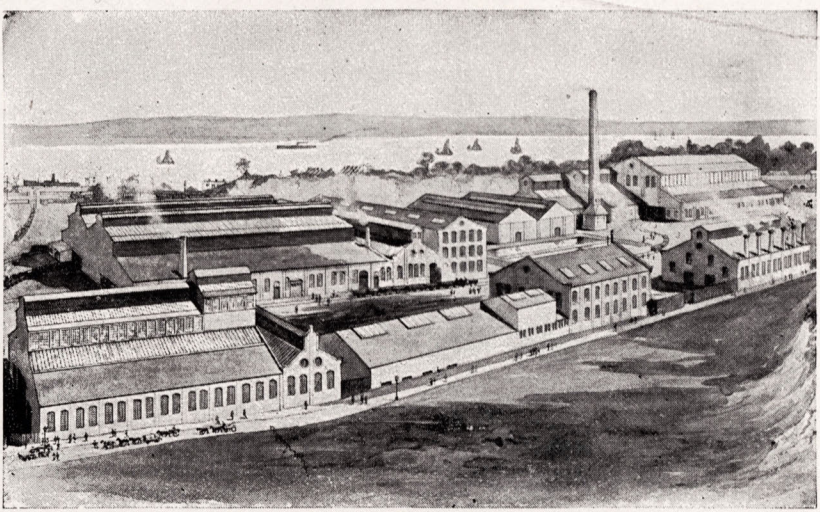

AT ERITH, KENT, ENGLAND.

SEDERHOLM BOILERS

TABLE OF CONTENTS

	PAGE
Business Notice	4
The Sederholm Boiler—Introductory	7
What is Required to Make a Good Boiler	8
Description of the Sederholm Boiler	19
Advantages of the Sederholm Boilers	24
A Sederholm Boiler Plant	29–32
Machinery Supplied with Steam by Sederholm Boilers	33, 36

USEFUL TABLES

Properties of Saturated Steam	37–40
Equivalent Evaporation	41
Steam and Coal Required for Lifting Water	42
Weight of Water per Cubic Foot	43
Temperature of Fire	43
Contents of Pipes and Cylinders	44
Mean Effective Pressures in Engines	45
Measures of Work, Power and Duty	45
Barometric Readings	46
Catalogues Published by Fraser & Chalmers	Inside Back Cover

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New catalogue issues displacing previous ones will retain the same catalogue numbers as the ones displaced, but will be given the next higher serial number. The first catalogue issued for any line of machinery being numbered, succeeding editions keep the same catalogue number but are given serial numbers, *i. e.*, Second, Third, Fourth, etc.; so as to show the number of the edition. The last edition of any catalogue will always take the place of all previous editions.

Designs illustrated in catalogues are at all times subject to modification in details. It should be borne in mind that deviation from standard sizes and types of machinery usually causes delay and additional expense.

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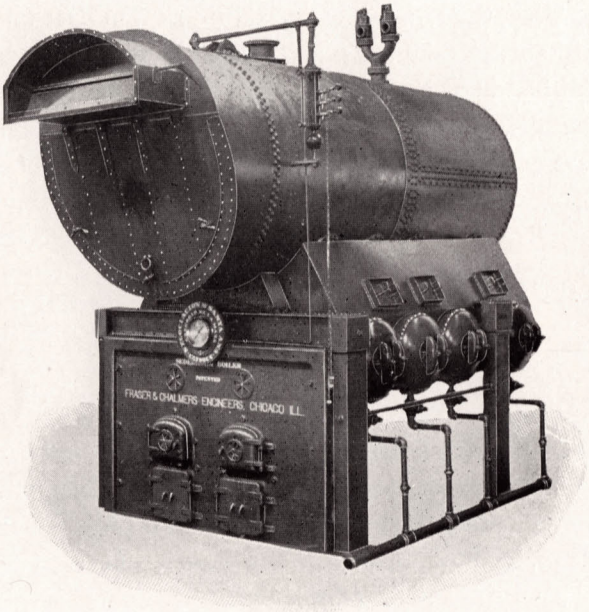
FRASER & CHALMERS'

SEDERHOLM BOILER

(PATENTED)

PLATE 800.



SHOWING BOILER SET UP READY FOR BRICK WORK.

THE SEDERHOLM BOILER.

The Sederholm Boiler has been designed to meet the growing demand for a high class steam generator, capable of working up to the highest pressures used in these days, while still retaining the well-known advantages of the *standard horizontal tubular boiler.*

The horizontal tubular boiler is not without its defects, yet its great economy and simplicity has maintained it in almost universal use until the present time. But the requirements of modern engineering become more exacting every day, and the tendency is toward higher pressures as well as toward concentration of more and more power into a given space.

The French, or elephant boiler was a step in this direction, and for fuel economy it leaves little to be desired. It would undoubtedly have obtained a very much more extended use were it not for its lack of circulation, and because it cannot be built in the large units required to-day.

These exacting conditions have driven engineers to the use of the different types of water tube boilers, which with all their faults, i. e.—wet steam, small reserve power, and numberless joints—have at least the advantage of being able to work under the highest pressures and of taking up comparatively small space.

The Sederholm Boiler combines the advantages of all these systems without possessing their defects. We can confidently recommend it to the use of the steam-using public as by far the best steam generator, wherever economy, durability and concentration of power is a consideration.

WHAT IS REQUIRED TO MAKE A GOOD BOILER?

Of all the hundreds of different boiler types that have been introduced, there are few which have not at least one point of merit, although only too generally their designers have failed to realize the importance of the other merits in which they are totally lacking. In order to produce a perfect boiler it is therefore first necessary to know just what is desirable and what should be avoided, and such a knowledge is equally important to the intending purchaser as to the builder.

First of all, it is, of course, necessary that the boiler may be relied upon to supply at all times the required amount of steam. This may seem like a truism and yet the requirements to fulfill this duty are too often lost sight of. It is not enough to supply a large amount of heating surface, but this surface must be so arranged that it is useful, as will be seen later on.

THE FURNACE

must be so arranged that the necessary quantity of coal can be burnt without difficulty, and without unnecessary losses. This does not mean merely a large grate area, but, especially for soft coals, it renders necessary a high fire-box, leaving ample room for the flames to expand. It is also very important that the *flame itself* should come in contact with *as little cold surface* as possible, and especially that the flames should nowhere be forced through narrow spaces either inside or outside of small tubes. The flames should be allowed the utmost freedom to expand, *until* they have burned out. After that the hot gases should be made to yield up their heat as quickly and as completely as possible.

GRATE AREA

depends chiefly upon two things; kind of fuel and intensity of draft. In a general way it may be said that the lower the grade of fuel, or the feebler the draft, the larger must be the grate. Still it is always well

to keep this area as small as practicable, since only thus can a high temperature be maintained in the furnace. Anthracite coal furnishes an exception to this rule, for with it a large grate is necessary, notwithstanding the high quality of the fuel. With good bituminous coals from twenty to twenty-five pounds per hour can readily be burned per square foot of grate surface, with a chimney from one hundred to one hundred and fifty feet in height. This rate of combustion is such as to produce a very high economy, and this economy will not vary greatly, whether the boiler be working considerably below its normal capacity or up to its very maximum.

An equally high degree of economy may be obtained by just about doubling the grate surface, so as to burn only from ten to thirteen pounds of coal per square foot per hour. This is due to the fact that most coals possess two distinct rates of combustion, each of which produces about equal results, which results are about the best that can be obtained. The lower rate, however, is less desirable practically, because a heavy loss takes place wherever the boiler is worked much below its normal capacity.

There are, however, cases in which it becomes absolutely necessary to largely increase the grate area. Coals containing a considerable percentage of sulphur must necessarily be burned slowly, or endless troubles from clinkers and burnt grate bars will result.

From these considerations it is clear that the grate area is dependent upon the kind of fuel, the height of stack, and, of course, upon the quantity of steam to be produced; but it does not stand in any direct relation to the extent of the heating surface, as is so often erroneously supposed.

PROPORTION OF HEATING SURFACE TO GRATE AREA

is, as just hinted, often made much of, but *in itself* it means nothing. The grate area depends entirely upon the fuel and the combustion, while the heating surface depends not only on the thoroughness with which it is desired to utilize the heat generated by the fuel, but also, in equal degree, upon the effectiveness of each separate part of the heating surface, as will be shown presently.

This is also the reason why such an apparent discrepancy is found in this ratio of heating surface to grate area, not only in boilers of different types, but often also in boilers of the same type.

THE HEATING SURFACE

may be divided into two general divisions—direct and indirect. Direct heating surface is all that part which is subjected to the direct radiation from the incandescent bed of fuel; indirect is that part which absorbs heat merely through contact with the hot gases. There is generally also a small zone which is exposed to the radiating effect of the flames, without being located directly above the bed of fuel, and this kind of surface is mostly classed as direct, although as a rule its heat absorbing value is somewhat lower.

The value of the direct surface is far greater than that of the indirect, and this comparative value varies between the ratios of 20 to 1 and 8 to 1, depending partly upon the kind of fuel used and partly upon the construction of the boiler. It is greater the hotter the bed of incandescent fuel, and also the more squarely the heat can radiate against the surface.

The indirect heating surface, to be of most value, should be such as to break up the mass of hot gases as much as possible, so as to bring each and every particle of gas into intimate contact with the heating surface. It should be as thin as possible, so that heat may not be wasted in penetrating a thick shell, and lastly, but equally important, it should not begin before combustion is completed; otherwise the flames are extinguished by being cooled too soon, and a great waste takes place through imperfect combustion.

INSIDE AND OUTSIDE HEATING SURFACE

The question whether the inside or the outside surface of a tube should be considered as the true heating surface has led to endless discussions, and yet the matter is simple enough if only rightly considered.

The heat, in passing from the fire into the water, meets with three separate sources of resistance. First, the resistance in passing from the fire into the metal of which the heating surface is formed; second,

the resistance in passing through the metal; and third, the resistance in passing from the metal into the water. (In cases of boilers in a dirty condition, the resistance of the soot and the scale, is of course, added.)

Of these three subdivisions of resistance the second is by far the smallest; in fact, under ordinary conditions, of so little importance as to be entirely overshadowed by the other two. Of these again, the first is several times as large as the third, and it therefore follows that the main thing to be considered is how to get the heat into the metal; if once in, it is comparatively easy to convey it to the water. And, since the comparative difference in extent between the inside and outside surface is never great, it follows that *the fire side* is the one that should be considered in every case, whether it happens to be the internal or the external surface. The only exception to this rule is for direct heating surface, but here a difference of opinion could not easily arise.

These considerations also explain why it is that iron and steel tubes have been found to be more effective than tubes of brass or copper, notwithstanding the inferior conductivity of the former. This lack of conductivity of iron and steel is more than made up by the greater readiness with which their rougher surfaces receive the heat from the gases of combustion.

And yet, while the above method of figuring heating surface is the more correct, it has not met with general favor because of its being more laborious, and the almost universal custom is, therefore, in every case, to measure the outside surface of a tube, whether it be fire side or water side.

SOOTING

takes place more or less in every boiler, and is always a detriment. Soot is a very poor conductor of heat, and any considerable deposit of soot has, therefore, a very detrimental effect upon the economy of a boiler. It is best and most thoroughly avoided by so designing the boiler that combustion is complete and as nearly smokeless as possible. Care should also be taken to avoid any surface so located as to be protected from the draft; in other words, the gases of combustion should be compelled to sweep over every part of the heating surface, and thus, in a great measure, to assist in keeping it free from soot.

This is very important even where a comparatively slight amount of sooting takes place, because light ashes act in much the same way as soot and must be guarded against. For this reason it is also imperative that a boiler be so constructed that any deposit that may form may be readily and completely removed while the boiler is in operation. It is not sufficient that it can be reached by a steam or air blast, but it must be accessible also to scraping tools and brushes, otherwise the cleaning will be very imperfect.

CIRCULATION

Just as soot and ashes prevent the fire from properly reaching the heating surface so does any non-conducting deposit on the water side of the heating surface, in a greater or lesser degree, prevent the heat from being transmitted to the water. According to the popular idea the only obstruction of this kind is scale, and this will be dealt with shortly. There is, however, another adherent, and this may be found even in the very cleanest boilers. This non-conductor is steam itself, which, in the shape of bubbles, has a tendency to stick to the surfaces on which it was first formed. This tendency is increased wherever there is a lack of circulation, and there these steam bubbles are found hanging to the sheet in very much the same way as air adheres to the side of a glass of spring water, after it has been allowed to stand for a few hours.

That the insulating effect of these bubbles is very great is proved by the fact that it has been found that the effect of each square foot of heating surface is often more than doubled by proper circulation. In other words, a boiler with good circulation may properly be built with only one-half the amount of heating surface necessary for one where the circulation is faulty, and still give the same economy.

Circulation, further, may prevent scale from adhering to the shell, and, judiciously contrived, may be made the means of carrying all sediment to those parts of the boiler where it will do the least harm.

Perfect circulation also promotes dryness of steam and prevents foaming and priming. When not due to impurities in the water, these latter faults are generally due to the difficulty the steam bubbles find in freeing themselves from the heating surface. They hang on until

they become too large to adhere longer, and it is just their large size which produces the priming. Where the circulation is good the bubbles are swept upward to the steaming surface as fast as they are formed.

PRIMING

is, however, also caused by cramped passages at the places where the steam has to rise through the water. This is an especial fault of the numerous class of boilers where *all the steam* has to ascend *at one end* of the boiler.

SCALE

is certainly one of the worst foes to good economy. While its detrimental action is often overstated, it is bad enough to cause, on an average, a loss in economy of fully 15 per cent. This shows the immense importance of adopting such construction as will reduce the incrustations to the smallest amount, and will insure their deposit in places where they do not affect the safety or economy of the boiler, and from which they can be removed by a periodical blowing off.

DRY STEAM

To perfectly fullfill its object a steam boiler must furnish dry steam, that is, steam which is free from entrained water (mechanically mixed with the steam). Any considerable quantity of such entrained water has a very injurious effect on the economy and smooth running of the engine in which it is used. The first is due to the fact that wet steam has the effect of largely increasing the loss through cylinder condensation. The smooth running is spoiled by the water mechanically washing away the oil from valve and cylinder surfaces, often causing a groaning sound which can be heard at a great distance. Cylinders have been ruined in a very short time from this cause.

Dry steam is obtained by so constructing the boiler that steam alone shall rise above the water surface, without carrying up with it any of the water from which it is generated. It has been found quite impossible afterward to separate entrained water from steam with any degree of completeness, if it is present in considerable quantity and has been intimately mixed with the steam. As has already been

stated, good circulation is one of the best known means for preventing wet steam, but alone it is insufficient. In addition, it is also imperatively necessary *that the liberating surface through which the steam passes should be large*, and that the steam should rise as nearly as possible equally over its whole extent, not all in the extreme end, as is often the case.

A LARGE STEAM SPACE

also tends to insure the delivery of dry steam. If the demand on the boiler were perfectly constant, then a small steam space would not be so hurtful; but, even with a so-called steady load, the demand varies from almost zero to the maximum twice during every revolution of the engine. Furthermore, a large steam space becomes a matter of supreme importance wherever there may be any sudden demand for increased power, as in an electric railway station, a saw-mill, or a hoisting plant. It is a well-known fact that in such cases a small steam space results in a large body of water being drawn up with the steam and into the engine every time the heavy load comes on. This has resulted in break-downs in numerous cases.

A LARGE WATER SPACE

has a regulating effect in some respects similar to that of a large steam space. It forms a reservoir for heat, stored up ready for instant use whenever there is a sudden call for more steam. It responds more quickly by far than the fire can be made to do, because time is required to change the condition of the fire.

PROPER CROSS SECTION OF TUBES

is also a very important consideration. This area must be large enough to allow the gases free passage, but at the same time, it is of extreme importance that the total opening be not too large, otherwise the gases will take a short cut through the tubes most nearly in line with their natural flow, leaving the other tubes perfectly dead and ineffective. Some otherwise good boilers are suffering from this defect to such an extent that, notwithstanding an unusually large heating surface, the gases of combustion leave the boilers at an abnormally high tempera-

ture, having passed over only a small portion of the heating surface, leaving the rest ineffective.

A slow speed of the gases through the tubes is detrimental also in another way, even where it may be secured without the drawback just mentioned; the slower the speed of the gases the greater will be the ease with which soot and ashes will deposit on the heating surface, resulting, as has been shown, in loss in economy. This fault should, therefore, be carefully guarded against, and this can be most readily done by maintaining a steady and sufficient current during the whole passage of the gases of combustion over the heating surface.

DIAMETER OF TUBES

depends upon several different considerations, and no one diameter can be said to be best in all cases. The diameter to a certain extent determines the quantity of heat-bearing gases that can enter the tube; but this quantity is also dependent upon the draft. The more heat enters the tube the larger must be the total surface in order that the heat may be properly absorbed. In other words, the larger its diameter or the stronger the draft, the longer should the tube be.

This is the reason why the tubes used on locomotives (not always on stationary boilers of the locomotive type, however) are small in diameter and long, while those in Scotch marine boilers are large in diameter and short.

It is also clear that circulation plays a very important role in determining the proportionate length of a tube. As has already been shown good circulation very materially increases the effectiveness of the heating surface, and consequently the better the circulation the shorter in proportion to their diameter may the tubes be. The whole matter resolves itself simply into providing *sufficient* tube *surface* to economically absorb the heat that enters the tube. The diameter will therefore have to be different for different conditions.

ACCESSIBILITY

is another feature which is of very great importance, and the durability of the boiler depends, in a very large measure, on this. It is, of course, especially necessary that the surfaces in direct contact with the

flames should be easily accessible for frequent inspection, and the access to them should be such that an experienced man may enter the boiler, and that the work will not have to be left to a boy whose only fitness is in his small size.

CLEANING

The cleaning of a boiler is of two kinds, self-acting and by hand. The former is never sufficient to keep a boiler free from scale, but by paying careful attention to the circulation of the water in the boiler, as well as to the manner of entering the feed water, the boiler may be so constructed that whatever scale may form will settle in such parts of the boiler that it will be comparatively harmless, or may even be blown off in the shape of mud.

But cleaning should not be confined to the water side of the boiler surfaces. It is equally important to keep the fire side of the heating surface free from soot. This is accomplished partly by compelling the gases of combustion to sweep at a fair rate of speed across all parts of the heating surface, and partly by so constructing the boiler that the fire side may be effectually scraped clean. Mere blowing off with a steam blower is entirely insufficient, except to take off the latest deposit of soot; after this has been done, the remainder of the soot should be loosened by means of a scraper, and then blown off with the steam blower.

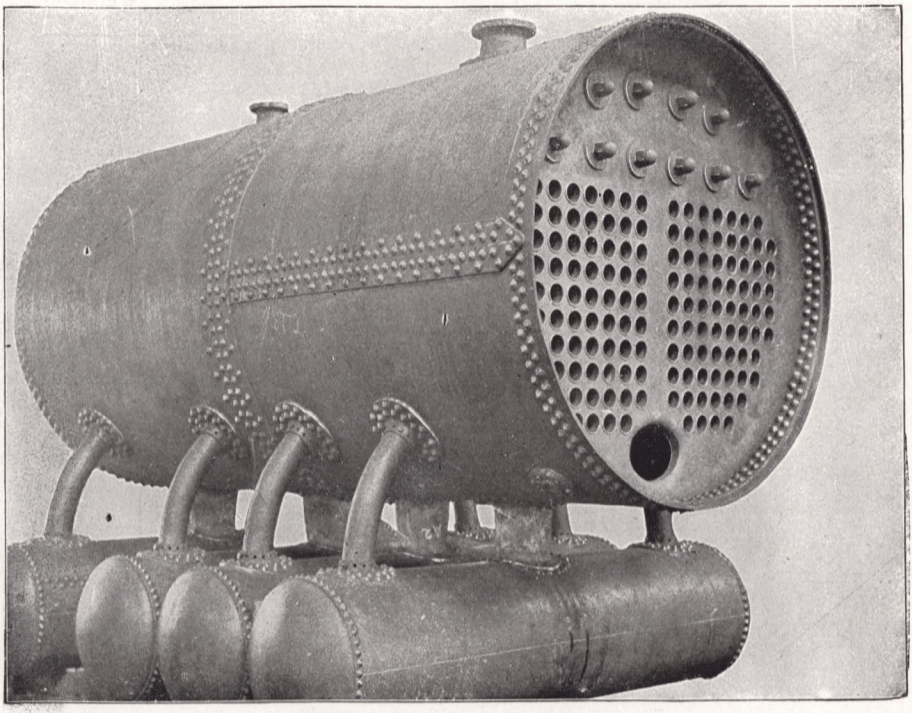
The above remarks will suffice to give an idea of the main points to be kept in view when designing a new boiler, or when selecting one for a power plant. They have been confined entirely to stationary boilers, so as not to unnecessarily confuse the reader. For marine or locomotive boilers still other considerations become important, but the conditions named apply even to such boilers. In the following pages we give a description of the construction of the Sederholm boiler, and demonstrate in how far the points named above have been kept in view.

FRASER & CHALMERS'

SEDERHOLM BOILER

(PATENTED)

PLATE 638.



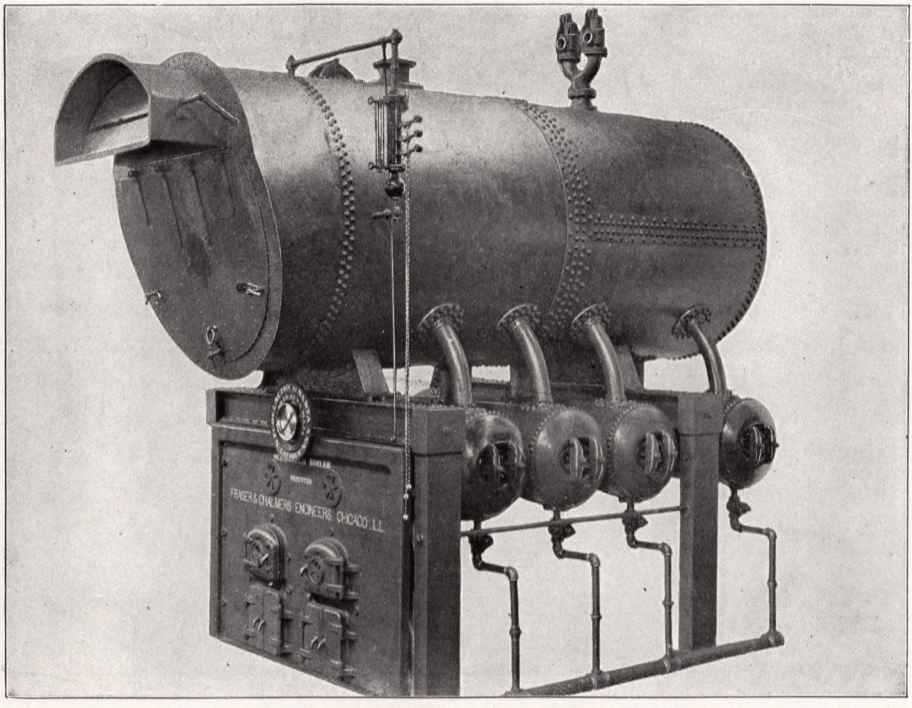
MAIN SHELL WITH FURNACE DRUMS.

FRASER & CHALMERS'

SEDERHOLM BOILER

(PATENTED)

PLATE 637.



SHOWING BOILER SET UP READY FOR BRICK WORK.

DESCRIPTION OF THE SEDERHOLM BOILER

This boiler consists mainly of a tubular boiler of large diameter connected to a series of cylindrical drums placed underneath, as shown in the illustration, plate 637, on page 18. The object of this construction is to provide a roof, constructed of thin material, over the whole furnace, and to shield the thick shell of the large boiler from the action of the flame.

It is just herein that the main difference lies between this boiler and the ordinary horizontal tubular boiler. The latter is placed directly over the fire, which is made to sweep under its full length, and afterward to return through the tubes. This is well enough up to a certain size and pressure, but for large dimensions or high pressures the shell has to be made so thick that its outer surface is no longer sufficiently cooled by the water on the inside, and is therefore rapidly burned away by the flames. In the Sederholm boiler the main shell is protected by the furnace drums beneath it, and can therefore be made of any required thickness. For this reason this boiler can be built of any desired size and for high pressures, without the slightest danger of damage.

THE MAIN SHELL

is built up of several courses, and is practically a large tubular boiler so arranged that the fire will sweep through its tubes after having passed beneath the furnace drums. This main shell is provided on the under side with openings connecting it with the furnace drums, and these openings are carefully reinforced so as not to weaken the shell in the least.

THE TUBES

are arranged in two nests, with a wide space for circulation between them, and they are furthermore placed so far away from the shell that all danger from leakage in consequence of too much stiffness is avoided.

They are carefully expanded into drilled holes in the tube sheets, after which they are neatly beaded over, as can be seen from the cut, plate 638, page 17. This cut shows also that a large space is left beneath the tubes for cleaning purposes.

THE FURNACE DRUMS

As shown in the illustration, plate 637 on page 18, these are of comparatively small diameter. They are placed across the furnace, close together, so as to form a continuous roof over the fire, except that between the two last drums sufficient space is left for a bridge wall and arch. Being of small diameter they need not be thick, and are therefore especially well adapted to withstand the action of the fire.

Each drum is connected with the main shell by means of three pipes, of which the central one is continued inside the drum and reaches to within a few inches of its bottom. Those at the ends, consisting of bent tubes, start from the tops of the drums and lead to the under side of the main shell, well below the water line. By this means a very efficient circulation is secured, as will be described later.

The drums are of sufficient size to easily admit a man to clean them when necessary, for which purpose each one is provided with a suitable manhole. They are further so constructed that no seam is in the fire, the longitudinal seams being on top and the circular seams at the ends, well out of range of the flames. The heads are dished so as to require no stays, and there is, therefore, nothing but a plain, thin cylindrical sheet exposed to the fire.

CIRCULATING PIPES

As already described, the drums are connected to the main shell by means of a series of circulating pipes. These pipes are provided with flanges which fit others riveted to the drums and boiler shells. The pipes are fastened by bolts as in ordinary piping. Gaskets are used to insure tight joints, so that in making these joints perfectly tight, there is no more difficulty than there is in the simplest line of piping.

The central pipe of each drum reaches almost down to the bottom part of the drum, while the side pipes stop at the top of the drum. In

this manner a very effective circulation is secured, the solid water coming down through the center tube and flowing toward the ends of each drum, from which it rises through the side pipes, together with all the steam made in the drum. The side pipes are curved, as shown, so as to be perfectly elastic, and not to oppose the free expansion of the furnace drums and the main shell.

CURRENT DEFLECTORS

Just inside the main shell, at the places where the side pipes enter, curved deflectors are provided to guide the current of water and steam upward in the wide space between the boiler tubes and the shell.

BOILER SUPPORTS

The boiler is supported on a structure built of iron and steel, entirely independent of the brickwork. There are four cast iron columns, on which rest two girders of heavy I beams. The boiler shell itself rests in chairs made of boiler plate; the rear chair rests solidly on its girder, while between the front chair and its girder a set of rollers is interposed, so as to leave the boiler perfectly free to expand and contract. The general design of this supporting structure is clearly shown in the cut, plate 637 on page 18.

BOILER FRONT

The boiler front is made of such size as to entirely cover the brickwork. It is of plain yet substantial design, and is provided with special air registers in addition to and above the usual fire and ash doors. Above these is a bracket for carrying the steam gauge, which is thus placed low enough to be seen without any difficulty whatever by the fireman.

THE FURNACE

is made with an unusually high fire-box, no part of the furnace drums being nearer than three feet to the grate bars. At the rear there is a bridge wall provided with arched openings through which the flames are made to pass. Behind the last furnace drum there is a second

bridge wall forming the front end of the return chamber, which is built of brick, at the rear end of the boiler.

The grate area is, in each case, carefully proportioned to the work the boiler has to perform, as well as to the height of the chimney and the kind of fuel which it is intended to use. Plain grates are furnished unless otherwise specified, but any kind of a special grate or furnace may, if desired, be fitted to this boiler.

BACK ARCH

The top of the brick return chamber is roofed over by a curved, cast iron skeleton back arch of such a length as to cover the whole width of the return chamber. This arch is loosely attached to the end of the boiler.

SMOKE BOX

At the front end of the boiler there is a sheet steel smoke box, provided with a large door for cleaning the boiler tubes. The uptake of this smoke box is generally placed on top; but where the head room does not permit of this, it may be placed as on plate 637, which shows the smoke box for a boiler to be located in a mine. The uptake is provided with a damper in the usual way.

BOILER STAYS

The flat heads of the main shell are braced, above the tubes, by means of strong stay-rods, running the full length of the boiler, as is usual in marine practice. (In the smallest sizes, ordinary braces are used instead of these.) Each stay is provided with nuts both inside and outside of the tube sheets which are reinforced by means of plate washers, riveted on.

DRY PIPE

Inside the boiler, in its highest portion, is a dry pipe so connected that the steam is taken only from the highest part of the boiler. This dry pipe connects at one end to the main steam nozzle and at the other end to the safety valve nozzle. Any unusual amount of water that may be picked up with the steam when the safety valve blows off

would therefore be immediately discharged through the safety valve instead of passing over to the engine.

MANHOLES

There is one manhole on the top of the main shell, and one below the boiler tubes, at the front end of the boiler. In addition, there is one manhole placed in the head of each of the furnace drums. These latter manholes are dispensed with when the boilers have to be set in very cramped positions, and in their stead the center pipes, connecting the drums to the main shell, are formed so as to allow a man to enter the drums through them.

SOOT DOORS

Each boiler is provided with all the necessary soot doors for cleaning the boiler setting from soot and ashes, as the circumstances may require.

BOILER TRIMMINGS

With each boiler are furnished the usual boiler trimmings, consisting of one or more safety valves, according to size, a steam gauge with piping, water column with gauge glass and gauge cocks, feed valve with check, and proper blow off valves. Suitable tools for cleaning flues and fires are also furnished with each set of boilers, as may be required.

NON-CONDUCTING COVERING

The boiler is arranged to be covered three inches thick with first-class non-conducting covering. Suitable sheet iron supports for this covering are provided as shown on plate 800, page 6.

ADVANTAGES OF THE SEDERHOLM BOILER

In the following pages we propose to show in a few words, in how far the Sederholm boiler fulfills the requirements mentioned in the first part of the catalogue, which requirements it has been our aim to fulfill in every particular.

THE FURNACE

is exceptionally high and therefore especially well adapted to all kinds of soft coal and wood, while at the same time a high fire-box is, of course, fully as advantageous as a low one, even for such coal as anthracite. From the fire-box itself the flame has a clean sweep underneath the whole length of the boilers or rather its furnace drums. This gives the flames about twenty feet in which to expand, and this distance is sufficient for any ordinary coal; at the same time, for such fuel as cannel coal, there is no difficulty whatever in still further increasing this length, and it will therefore be seen that this boiler offers unusual advantages for the utilization of bituminous or other long flaming fuel.

Aside from its unusual height the furnace is further so arranged as to bring the gases of combustion into close contact with the air. The whole amount of gas and air is made to pass through a comparatively narrow opening, where they are intimately mingled, and where a lively combustion takes place, and a high temperature, which is so essential to good economy, is attained.

THE DIRECT HEATING SURFACE

is not only unusually large, but it is also presented to the fire in the most advantageous manner. It is formed entirely by the furnace drums, extending crosswise over the furnace beneath the boiler. Due to this arrangement, they receive vertical rays from all parts of the incandescent bed of fuel, thus utilizing the radiated heat in the best

possible manner. This part of the heating surface is at the same time so arranged that the flames themselves touch it as little as possible, this being for the purpose of not interfering with the combustion more than is necessary. The result is that the combustion is almost perfectly smokeless, without the aid of any special smoke-consuming device.

INDIRECT HEATING SURFACE

This part of the heating surface consists of fire tubes in the main shell, as explained in the previous description of the boiler. Of all the known surfaces, this is probably the most efficient, because the metal can be made very thin and is therefore unusually well adapted to extract the last heat from the gases. This indirect heating surface begins, as we have described, at such a distance from the furnace that the flame has had ample time to burn itself out before entering the tubes. There is therefore no danger of cooling the flame before combustion is completed, and the result is a high degree of economy.

FREEDOM FROM SOOT AND ASHES

From the construction of this boiler, it will be easily seen that there is very little chance for soot and ashes to lodge, and that the only possible lodging places are easy of access; the only place where soot and ashes may deposit themselves is in the fire tubes. These can easily be reached through the flue doors either by the steam blower or by the usual scrapers and brushes, which are all furnished with the boiler. The cross section of tubes, however, is so proportioned that a lively draft exists in every tube. This results in by far the greater part of all soot and ashes being blown out into the smoke stack, where it is out of harm's way. As far as soot is concerned, the boiler is very free from this, due to the fact that very little soot is formed.

CIRCULATION

It will be remembered that each fire drum is connected to the main shell by means of three pipes, the center one of which reaches through the top of the drum far into the same. The side pipes on the other hand start from the very tops of the furnace drums. All of these pipes

enter the main shell in the water space. The result of this is that all the steam made in the furnace drums, as well as the water, as it becomes heated, rises through the side pipes; the clear solid water constantly passing down through the center connection. The effect of this is to produce a constant current in each drum, from its center towards each end. This current sweeps all mud before it and lodges this mud in the very ends of each drum from which it is blown out by means of valves located there for this purpose. The settling of the mud at the ends is assisted by the eddy formed by the water as it turns from its horizontal, outward direction upward into the side pipes. It will also be noticed that the ends of the drums are removed from the fire so that no danger of burning out occurs from this deposit.

After the steam and the heated water pass into the main boiler the current is deflected upward by shields placed at each opening. In this manner a very effective circulation is obtained in the main boiler itself, helping in a great measure to increase the capacity of each square foot of heating surface, as well as insuring against foaming, with its consequence of wet steam.

FOAMING AND PRIMING

The large water surface of this boiler is a great safeguard against foaming. Not only is the water surface unusually large, but due to the construction of the boiler, a very nearly equal amount of steam is generated in every part of the boiler. The front furnace drums, located above the grate, evaporate very much more steam than the rear drums; on the other hand, the fire tubes evaporate several times as much steam at their rear ends as at the front.

It is this feature which makes the evaporation so uniform, and it is very largely due to this that the steam is so very dry, even when the boilers are forced beyond their rated capacity.

ACCESSIBILITY

From the illustrations and the description, it will be seen that it is possible to enter every part of this boiler through the manholes provided for such purpose. The furnace drums, which it is very important to keep clean, are very easy of access, each one of them having a

manhole at one end. They are also large enough to allow a man to enter with ease, and the work of cleaning can therefore be thoroughly accomplished without any difficulty whatever. The main shell can also be entered both above and below the tubes, which are placed far enough apart to allow of a comparatively easy cleaning in the usual manner.

LARGE STEAM SPACE

The main shell in this boiler is of such large diameter that it allows of an unusually large steam space. The steam is further taken from the very highest point of this steam space, so that dry steam is assured in every possible way. The steam space in the boiler itself is large enough for all practical purposes, and need not be further augmented by large and cumbersome steam drums, which in themselves are, through excessive radiation, a source of loss in economy.

WATER CAPACITY

The boiler will also be seen to belong to the class having a large body of water. This insures steadiness in working as we have seen. It would naturally be supposed that with such large water space an unusually long time would be required for getting up steam. As a matter of fact, however, a 350 horse power boiler of this kind attained 40 pounds steam pressure in 20 minutes after the boiler was started with cold water. This time is of course much shorter than prudence would dictate, and it is only mentioned in order to prove that this type of a boiler will make steam as fast as any other.

SPACE REQUIRED

This boiler takes up an unusually small floor space, a 350 horse power boiler requiring but little over 13 feet in width. It should be further noted that this small space is secured without resorting to the use of an unusually long grate, as is often done when a large boiler is to be crowded into a narrow space.

BRICK WORK

Another noteworthy feature of this boiler is that the boiler setting is only about seven foot high, except at the rear end where it forms a

return smoke chamber. This unusually low boiler setting has no weight to carry except its own, the boiler being supported entirely on structural iron work.

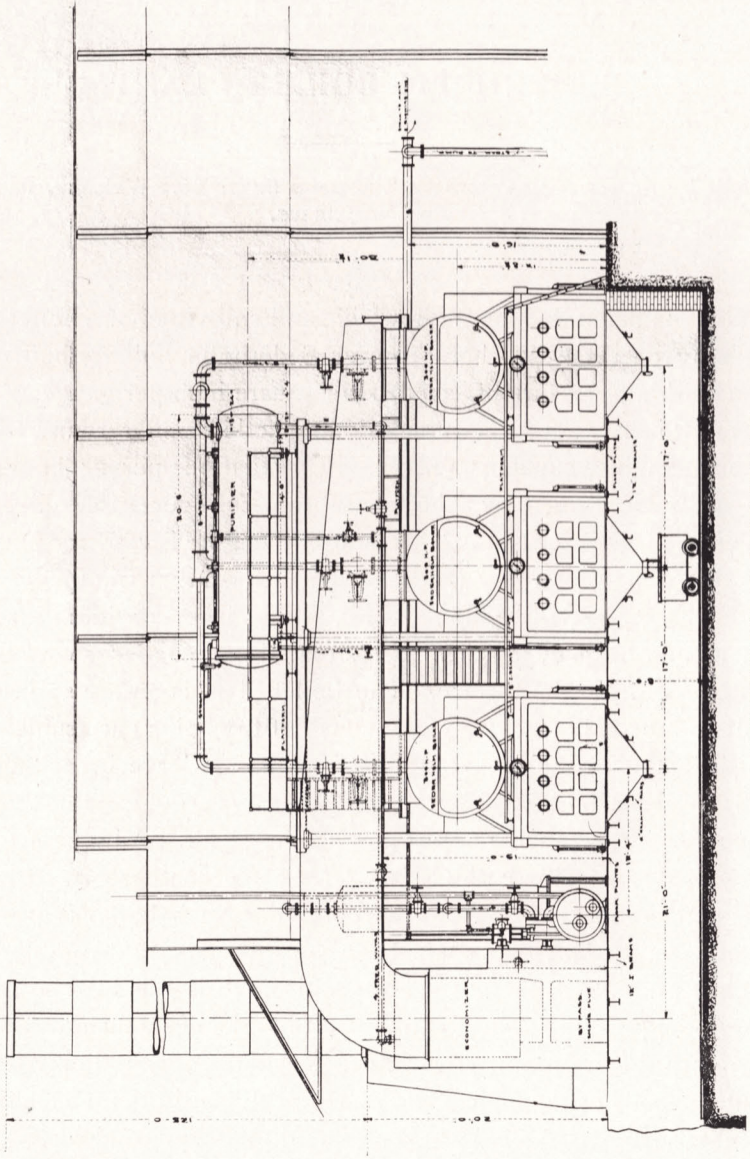
The boiler setting is therefore very durable. It is also very cheap, requiring as it does only about one half as many bricks as any other kind of boiler. This is also an important item, especially where bricks have to be transported a long distance.

In the preceding pages we have endeavored to give a clear idea of the requirements of a boiler plant as well as of the construction and the special advantages of the Sederholm boiler. In conclusion we would only say, that this boiler is constructed of the very best of materials, and that nothing but first-class workmanship enters into its construction. No pains are spared in making special designs to meet peculiar conditions, and we especially invite the investigation of all who are finding difficulties with other systems of boilers.

SEDERHOLM BOILER PLANT

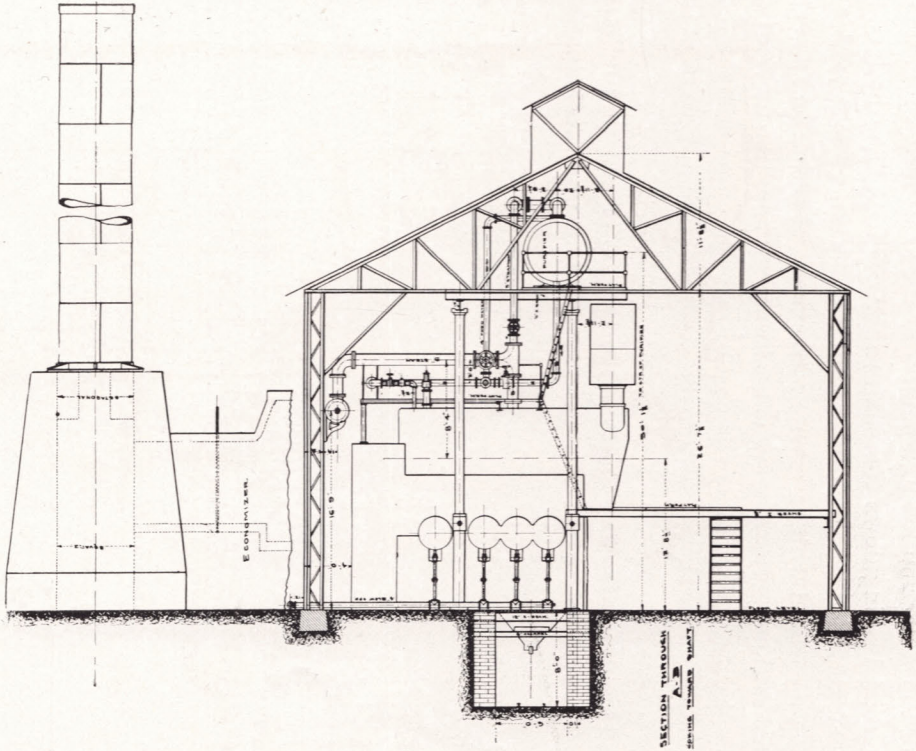
Built by Fraser & Chalmers for the Oahu Sugar Co., Waipahu, Oahu, Hawaiian Islands.

Cuts on pages 30 and 31 show side and end views of a boiler plant consisting of three 300 horse power Sederholm boilers, built for a steam working pressure of 180 lbs. per square inch per gauge. These boilers furnish steam for a duplex double acting underground Riedler pumping engine, capacity 12,000,000 U. S. gallons per 24 hours to a head of 755 ft , driven by a horizontal four-cylinder triple expansion condensing Corliss engine. This pumping engine is used for pumping irrigation water for sugar lands of the Oahu Sugar Company. It is one of the largest pumping engines, taking into consideration both capacity and head, ever built. It is situated in an underground station about 400 ft. from the surface. The boiler plant is on the surface and it will be noted is most complete. Two of the boilers are sufficient to furnish steam for the large pumping engine. A large breeching connects the three boilers and leads the waste gases of combustion into an economizer from where they pass to the stack. A by-pass for the economizer is provided which is placed underneath so as to reduce space and amount of brick work required. Each boiler is provided beneath the fire-box with conical ash pans fitted with drop doors. A trench is provided beneath the boilers in which is run a car to receive the dumpings from the ash pans. By this arrangement no ashes are drawn into the fire room. In front of the boilers at the lower level of the main shells of the boilers is a platform to facilitate the cleaning of the tubes. Above the boilers is a second platform so arranged as to permit of access to all stop valves and other steam valves. Above this platform is a third platform to permit getting at piping and the live steam purifier. The feed water is taken from a hot well which



SEDERHOLM BOILER PLANT.
Front Elevation.

PLATE 1104 B.

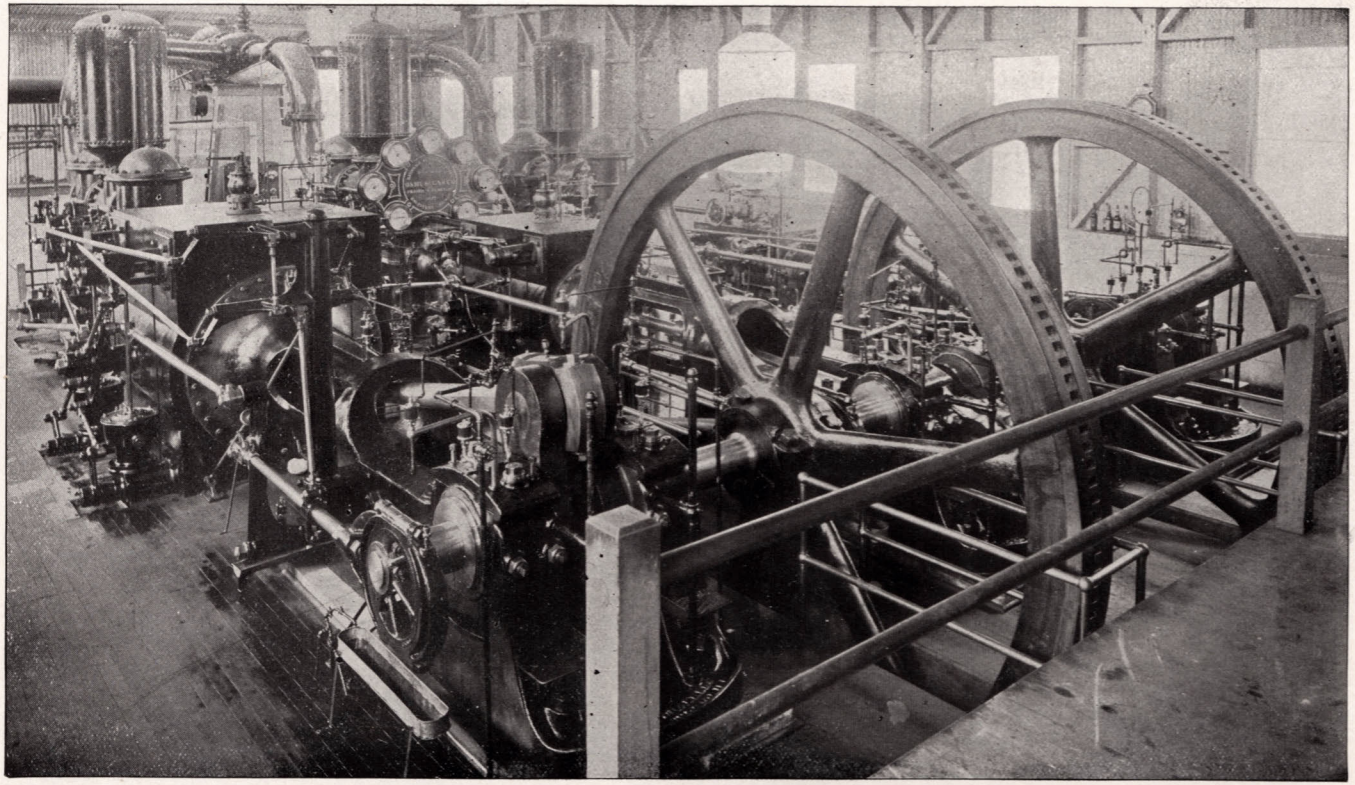


SEDERHOLM BOILER PLANT.

Side Elevation.

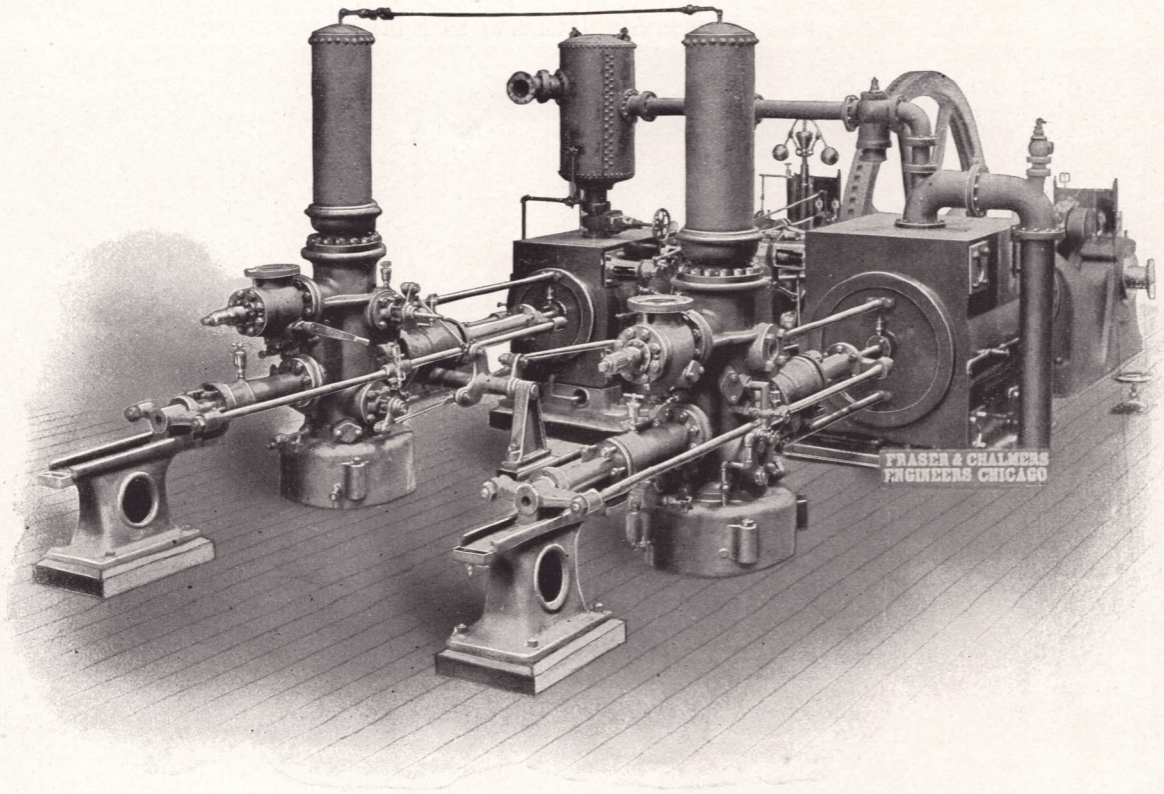
receives feed water supply. From thence it is taken by duplex double acting, outside packed, compound feed pumps and forced first through a Fraser & Chalmers Berryman feed water heater, then through the economizer, then into the live steam purifier above the boilers. From this purifier it is led into the boilers. The main steam header is placed back of the boiler and led to a point over the shaft where connects the steam pipe leading down the shaft to the engine. The boilers, feed water heater, feed water purifier and all main steam and feed water piping are covered with carbonate of magnesia covering on an average of 3 inches thick. No automatic coal and ash handling devices were furnished with this plant as the cost of installation as compared with the amount of coal and ash to be handled did not warrant such expense.

All parties intending to install power plants will find it to their interest to write Fraser & Chalmers for estimate on Sederholm Boiler.



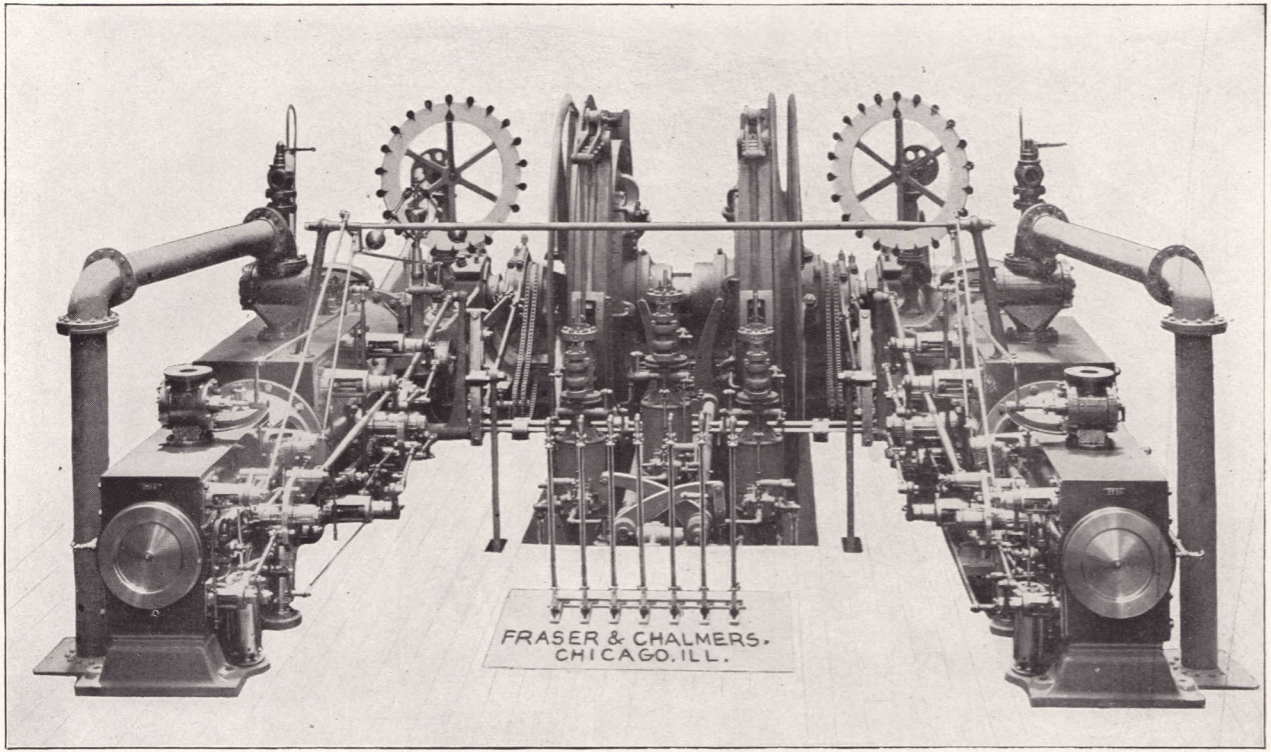
TEN MILLION GALLON TRIPLE EXPANSION RIEDLER PUMPING ENGINE

One of two duplicate engines built for the Oahu Sugar Co. Steam is supplied by two 350 H.-P. Sederholm Boilers, built for 180 pounds steam pressure.



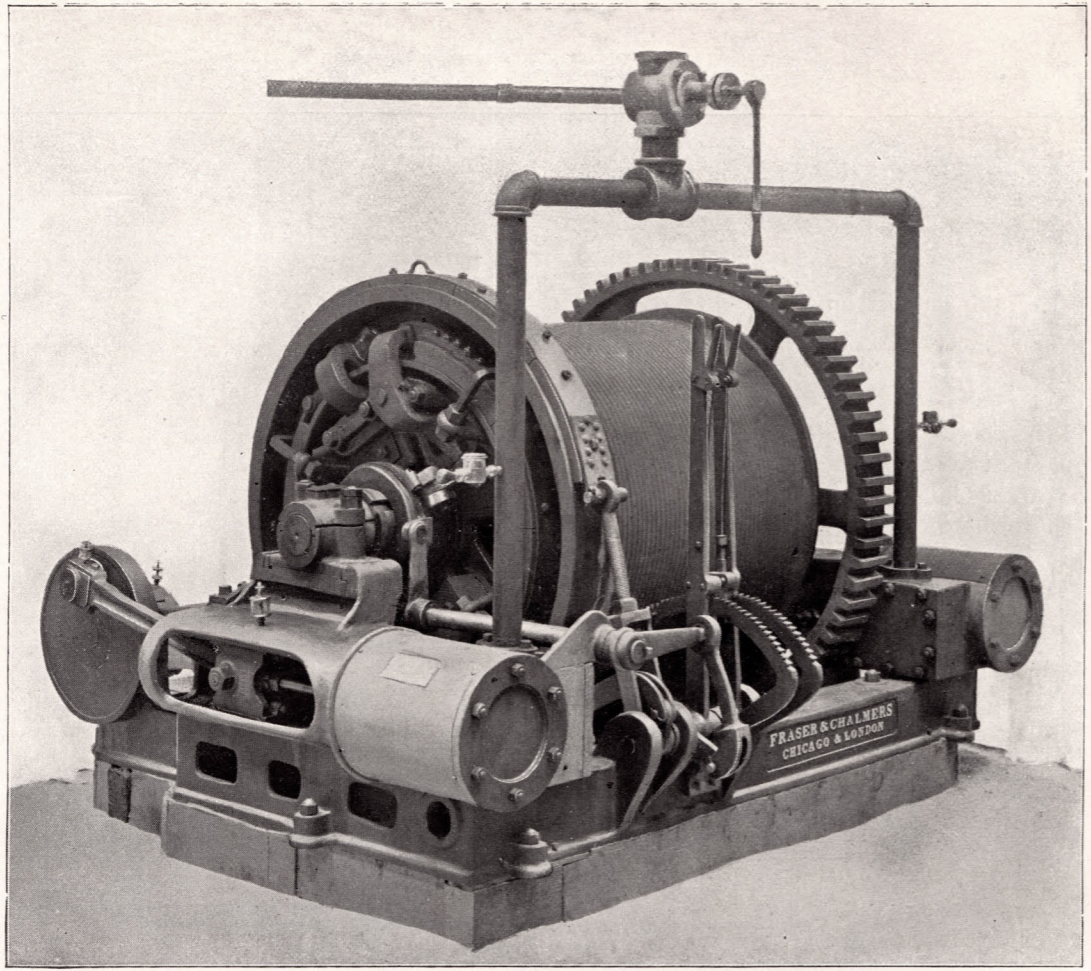
DUPLEX DIFFERENTIAL RIEDLER PUMP

Driven by a Cross-Compound Condensing Corliss Engine. Capacity, 600 gallons per minute, against a head of 1,654 feet, at 70 revolutions per minute.
Built by Fraser & Chalmers for Negociacion de Santa Ana Mine. Supplied with steam by Sederholm Boilers.



DIRECT ACTING DOUBLE REEL HOIST

Driven by Duplex Tandem Compound Corliss Engines, supplied with steam by Sederholm Boilers, built for 130 pounds pressure.
For the Negociacion de Santa Ana Company, Mexico.



TIMBER HOIST

Built by Fraser & Chalmers for the Negociacion de Santa Ana, Mexico. Steam for this hoist is supplied by a Sederholm Boiler.

PROPERTIES OF SATURATED STEAM

(From Chas. T. Porter's Treatise on the Richards' Steam Engine Indicator.)

Absolute Pressure.	Temperature.	Latent Heat.	Total Heat Above Zero.	Weight of One Cubic Foot.
Pounds per Square Inch Above Zero.	Fahr., Deg.	B. T. U.	Fahr., B. T. U.	Pounds.
1	102.00	1042.96	1145.05	.0030
2	126.26	1026.01	1152.45	.0058
3	141.62	1015.25	1157.13	.0085
4	153.07	1007.22	1160.62	.0112
5	162.23	1000.72	1163.44	.0137
6	170.12	995.24	1165.82	.0163
7	176.91	990.47	1167.89	.0189
8	182.91	986.24	1169.72	.0214
9	188.31	982.43	1171.37	.0239
10	193.24	978.95	1172.87	.0264
11	197.76	975.76	1174.25	.0289
12	201.96	972.80	1175.53	.0313
13	205.88	970.02	1176.73	.0337
14	209.56	967.42	1177.85	.0362
15	213.02	964.97	1178.91	.0387
16	216.29	962.65	1179.90	.0413
17	219.41	960.45	1180.85	.0437
18	222.37	958.34	1181.76	.0462
19	225.20	956 34	1182.61	.0487
20	227.91	954.41	1183.45	.0511
21	230.51	952.57	1184.24	.0536
22	233.01	950.79	1185.00	.0561
23	235.43	949.07	1185.74	.0585
24	237.75	947.42	1186.45	.0610
25	240.00	945.82	1187.13	.0634
26	242.17	944.27	1187.80	.0658
27	244.28	942.77	1188.44	.0683
28	246.32	941.32	1189.06	.0707
29	248.31	939.90	1189.67	.0731
30	250.24	938.92	1190.26	.0755
31	252.12	937.18	1190.83	.0779
32	253.95	935.88	1191.39	.0803
33	255.73	934.60	1191.93	.0827
34	257.47	933.36	1192.46	.0851
35	259.17	932.15	1192.98	.0875
36	260.83	930.96	1193.49	.0899
37	262.45	929.80	1193.98	.0922
38	264.04	928.67	1194.47	.0946
39	265.59	927.56	1194.94	.0970
40	267.12	926.47	1195.41	.0994
41	268.61	925.40	1195.86	.1017
42	270.07	924.35	1196.31	.1041
43	271.50	923.33	1196.74	.1064
44	272.91	922.32	1197.17	.1088
45	274.29	921.33	1197.60	.1111
46	275.65	920.36	1198.01	.1134
47	276.98	919.40	1198.42	.1158
48	278.29	918.46	1198.82	.1181
49	279.58	917.54	1199.21	.1204
50	280.85	916.63	1199.60	.1227
51	282.09	915.73	1199.98	.1251

PROPERTIES OF SATURATED STEAM—Continued.

Absolute Pressure.	Temperature.	Latent Heat.	Total Heat Above Zero.	Weight of One Cubic Foot.
Pounds per Square Inch Above Zero.	Fahr., Deg.	B. T. U.	Fahr., B. T. U.	Pounds.
52	283.32	914.85	1200.35	.1274
53	284.53	913.98	1200.72	.1297
54	285.72	913.13	1201.08	.1320
55	286.89	912.29	1201.44	.1343
56	288.05	911.46	1201.79	.1366
57	289.11	910.64	1202.14	.1388
58	290.31	909.83	1202.48	.1411
59	291.42	909.03	1202.82	.1434
60	292.52	908.24	1203.15	.1457
61	293.59	907.47	1203.48	.1479
62	294.66	906.70	1203.81	.1502
63	295.71	905.94	1204.13	.1524
64	296.75	905.20	1204.44	.1547
65	297.77	904.46	1204.76	.1569
66	298.78	903.73	1205.07	.1592
67	299.78	903.01	1205.37	.1614
68	300.77	902.29	1205.67	.1637
69	301.75	901.59	1205.97	.1659
70	302.71	900.89	1206.26	1681
71	303.67	900.21	1206.56	.1703
72	304.61	899.52	1206.84	.1725
73	305.55	898.85	1207.13	.1748
74	306.47	898.18	1207.41	.1770
75	307.38	897.52	1207.69	.1792
76	308.29	896.87	1207.96	.1814
77	309.18	896.23	1208.24	.1836
78	310.06	895.59	1208.51	.1857
79	310.94	894.95	1208.77	.1879
80	311.81	894.33	1209.04	.1901
81	312.67	893.70	1209.30	.1923
82	313.52	893.09	1209.56	.1945
83	314.36	892.48	1219.82	.1967
84	315.19	891.88	1210.07	.1988
85	316.02	891.28	1210.32	.2010
86	316.83	890.69	1210.57	.2032
87	317.65	890.10	1210.82	.2053
88	318.45	889.52	1211.06	.2075
89	319.24	888.94	1211.31	.2097
90	320 03	888.37	1211.55	.2118
91	320.82	887.80	1211.79	.2130
92	321.59	887.24	1212.02	.2160
93	322.36	886.68	1212.26	.2182
94	323.12	886.13	1212.49	.2204
95	323.88	885.58	1212.72	.2224
96	324.63	885.04	1212.95	.2245
97	325.37	884.50	1213.18	.2266
98	326.11	883.97	1213.40	.2288
99	326.84	883.44	1213.62	.2309
100	327.57	882.91	1213.84	.2330
101	328.29	882.39	1214.06	.2351
102	329.00	881.87	1214.28	.2371
103	329.71	881.35	1214.50	.2392
104	330.41	880 84	1214.71	.2413

PROPERTIES OF SATURATED STEAM—Continued.

Absolute Pressure.	Temperature.	Latent Heat.	Total Heat Above Zero.	Weight of One Cubic Foot.
Pounds per Square Inch Above Zero.	Fahr., Deg.	B. T. U.	Fahr., B. T. U.	Pounds.
105	331.11	880.34	1214.92	.2434
106	331.80	879.84	1215.14	.2454
107	332.49	879.34	1215.35	.2475
108	333.17	878.84	1215.55	.2496
109	333.85	878.35	1215.76	.2516
110	334.52	877.86	1215.97	.2537
111	335.19	877.37	1216.17	.2558
112	335.85	876.89	1216.37	.2578
113	336.51	876.41	1216.57	.2599
114	337.16	875.94	1216.77	.2619
115	337.81	875.47	1216.97	.2640
116	338.45	875.40	1217.17	.2661
117	339.10	874.53	1217.36	.2681
118	339.73	874.07	1217.56	.2702
119	340.36	873.61	1217.75	.2722
120	340.99	873.15	1217.94	.2742
121	341.61	872.70	1218.13	.2762
122	342.23	872.25	1218.32	.2782
123	342.85	871.80	1218.51	.2802
124	343.46	871.35	1218.69	.2822
125	344.07	870.91	1218.88	.2842
126	344.67	870.47	1219.06	.2862
127	345.27	870.03	1219.25	.2882
128	345.87	869.59	1219.43	.2902
129	346.45	869.16	1219.61	.2922
130	347.05	868.73	1219.79	.2942
131	347.64	868.30	1219.97	.2961
132	348.22	867.88	1220.15	.2981
133	348.80	867.46	1220.32	.3001
134	349.38	867.03	1220.50	.3020
135	349.95	866.62	1220.67	.3040
136	350.52	866.20	1220.85	.3060
137	351.08	866.79	1221.02	.3079
138	351.75	865.38	1221.19	.3099
139	352.21	864.97	1221.36	.3118
140	352.76	864.56	1221.53	.3138
141	353.31	864.16	1221.70	.3158
142	353.86	863.76	1221.87	.3178
143	354.41	863.36	1222.03	.3199
144	354.96	862.96	1222.20	.3219
145	355.50	862.56	1222.36	.3239
146	356.03	862.17	1222.53	.3259
147	356.57	861.78	1222.69	.3279
148	357.10	861.39	1222.85	.3299
149	357.63	861.00	1223.01	.3319
150	358.16	860.62	1223.18	.3340
151	358.68	860.23	1223.33	.3358
152	359.20	859.85	1223.49	.3376
153	359.72	859.47	1223.65	.3394
154	360.23	859.10	1223.81	.3412
155	360.74	858.72	1223.97	.3430
156	361.26	858.35	1224.12	.3448
157	361.76	857.98	1224.28	.3466

PROPERTIES OF SATURATED STEAM—Continued.

Absolute Pressure.	Temperature.	Latent Heat.	Total Heat Above Zero.	Weight of One Cubic Foot.
Pounds per Square Inch Above Zero.	Fahr., Deg.	B. T. U.	Fahr., B. T. U.	Pounds.
158	362.27	857.61	1224.43	.3484
159	362.77	857.24	1224 58	.3502
160	363.27	856 87	1224.74	.3520
161	363.77	856.50	1224.89	.3539
162	364.27	856.14	1225.04	.3558
163	364 76	855.78	1225.19	.3577
164	365.25	855.42	1225.34	.3596
165	365 74	855.06	1225.49	.3614
166	366.23	854.70	1225.64	.3633
167	366.71	854.35	1225.78	.3652
168	367.19	853.99	1225.93	.3671
169	367.68	853.64	1226.08	.3690
170	368.15	853.29	1226.22	.3709
171	368.63	852.94	1226.37	.3727
172	369.10	852.59	1226.51	.3745
173	369.57	852.25	1226.66	.3763
174	370.04	851.90	1226.80	.3781
175	370.51	851.56	1226.94	.3799
176	370.97	851.22	1227.08	.3817
177	371.44	850.88	1227.32	.3835
178	371.90	850.54	1227.37	.3853
179	372.36	850.20	1227.51	.3871
180	372.82	849.86	1227.65	.3889
181	373.27	849.53	1227.78	.3907
182	373.73	849.20	1227.92	.3925
183	374.18	848.86	1228.06	.3944
184	374.63	848.53	1228.20	.3962
185	375.08	848.20	1228.33	.3980
186	375.52	847.88	1228 47	.3999
187	375.97	847.55	1228.61	.4017
188	376.41	847.22	1228.74	.4035
189	376.85	846.90	1228.87	.4053
190	377.29	846.58	1229.01	.4072
191	377.72	846.23	1229.14	.4089
192	378.16	845.94	1229.27	.4107
193	378.59	845.62	1229.41	.4125
194	379.02	845.30	1229.54	.4143
195	379.45	844 99	1229.67	.4160
196	379.97	844.68	1229.80	.4178
197	380.30	844.36	1229.93	.4196
198	380.72	844.05	1230.06	.4214
199	381.15	843.74	1230.19	.4231
200	381.57	843.43	1230.31	.4249
201	381.99	843.12	1230.44	.4266
202	382.41	842.81	1230.57	.4283
203	382.82	842.50	1230.70	.4300
204	383.24	842.20	1230.82	.4318
205	383.65	841.89	1230.95	.4335
206	384.06	841.59	1231.07	.4352
207	384.47	841.29	1231.20	.4369
208	384.88	840.99	1231.32	.4386
209	385.28	840.69	1231.45	.4403
210	385.67	840.39	1231.57	.4421

FACTORS OF EQUIVALENT EVAPORATION

PRESSURE IN POUNDS PER SQUARE INCH ABOVE THE ATMOSPHERE

Temperature of Feed Water in Degrees Fahrenheit.

	0	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	120	140	160	180	200
32	1.187	1.192	1.195	1.199	1.201	1.204	1.206	1.209	1.211	1.212	1.214	1.217	1.219	1.222	1.224	1.227	1.231	1.234	1.237	1.239	1.241
35	1.184	1.189	1.192	1.196	1.198	1.201	1.203	1.206	1.208	1.209	1.211	1.214	1.216	1.219	1.221	1.224	1.228	1.231	1.234	1.236	1.238
40	1.179	1.184	1.187	1.191	1.193	1.196	1.198	1.201	1.203	1.204	1.206	1.209	1.211	1.214	1.216	1.219	1.223	1.226	1.229	1.231	1.233
45	1.173	1.178	1.181	1.185	1.187	1.190	1.192	1.195	1.197	1.198	1.200	1.203	1.205	1.208	1.210	1.213	1.217	1.220	1.223	1.225	1.227
50	1.168	1.173	1.177	1.180	1.182	1.185	1.187	1.190	1.192	1.193	1.195	1.198	1.200	1.203	1.205	1.208	1.212	1.215	1.218	1.220	1.222
55	1.163	1.168	1.171	1.175	1.177	1.180	1.182	1.185	1.187	1.188	1.190	1.193	1.195	1.198	1.200	1.203	1.207	1.210	1.213	1.215	1.217
60	1.158	1.163	1.166	1.170	1.172	1.175	1.177	1.180	1.182	1.183	1.185	1.188	1.190	1.193	1.195	1.198	1.202	1.205	1.208	1.210	1.212
65	1.153	1.158	1.161	1.165	1.167	1.170	1.172	1.175	1.177	1.178	1.180	1.183	1.185	1.188	1.190	1.193	1.197	1.200	1.203	1.205	1.207
70	1.148	1.153	1.156	1.160	1.162	1.165	1.167	1.170	1.172	1.173	1.175	1.178	1.180	1.183	1.185	1.188	1.192	1.195	1.198	1.200	1.202
75	1.143	1.148	1.151	1.155	1.157	1.160	1.162	1.165	1.167	1.168	1.170	1.173	1.175	1.178	1.180	1.183	1.187	1.190	1.193	1.195	1.197
80	1.137	1.143	1.146	1.149	1.151	1.154	1.156	1.159	1.161	1.162	1.164	1.167	1.169	1.172	1.174	1.177	1.181	1.184	1.187	1.189	1.191
85	1.132	1.137	1.140	1.144	1.146	1.149	1.151	1.154	1.156	1.157	1.159	1.162	1.164	1.167	1.169	1.172	1.176	1.179	1.182	1.184	1.186
90	1.127	1.132	1.135	1.139	1.141	1.144	1.146	1.149	1.151	1.152	1.154	1.157	1.159	1.162	1.164	1.167	1.171	1.174	1.177	1.179	1.181
95	1.122	1.127	1.130	1.134	1.136	1.139	1.141	1.144	1.146	1.147	1.149	1.152	1.154	1.157	1.159	1.162	1.166	1.169	1.172	1.174	1.176
100	1.117	1.122	1.125	1.129	1.131	1.134	1.136	1.139	1.141	1.142	1.144	1.147	1.149	1.152	1.154	1.157	1.161	1.164	1.167	1.169	1.171
105	1.111	1.117	1.120	1.123	1.125	1.128	1.130	1.133	1.135	1.136	1.139	1.141	1.143	1.146	1.148	1.151	1.155	1.158	1.161	1.163	1.165
110	1.106	1.111	1.114	1.118	1.120	1.123	1.125	1.128	1.130	1.131	1.133	1.136	1.138	1.141	1.143	1.146	1.150	1.153	1.156	1.158	1.160
115	1.101	1.106	1.109	1.113	1.115	1.118	1.120	1.123	1.125	1.126	1.128	1.131	1.133	1.136	1.138	1.141	1.145	1.148	1.151	1.153	1.155
120	1.096	1.101	1.104	1.108	1.110	1.113	1.115	1.118	1.120	1.121	1.123	1.126	1.128	1.131	1.133	1.136	1.140	1.143	1.146	1.148	1.150
125	1.091	1.096	1.099	1.103	1.105	1.108	1.110	1.113	1.115	1.116	1.118	1.121	1.123	1.126	1.128	1.131	1.135	1.138	1.141	1.143	1.145
130	1.085	1.091	1.094	1.097	1.099	1.102	1.104	1.107	1.109	1.110	1.112	1.115	1.117	1.120	1.122	1.125	1.129	1.132	1.135	1.137	1.139
135	1.080	1.085	1.088	1.092	1.094	1.097	1.099	1.102	1.104	1.105	1.107	1.110	1.112	1.115	1.117	1.120	1.124	1.127	1.130	1.132	1.134
140	1.075	1.080	1.083	1.087	1.089	1.092	1.094	1.097	1.099	1.100	1.102	1.105	1.107	1.110	1.112	1.115	1.119	1.122	1.125	1.127	1.129
145	1.070	1.075	1.078	1.082	1.084	1.087	1.089	1.092	1.094	1.095	1.097	1.100	1.102	1.105	1.107	1.110	1.114	1.117	1.120	1.122	1.124
150	1.065	1.070	1.073	1.077	1.079	1.082	1.084	1.087	1.089	1.090	1.092	1.095	1.097	1.100	1.102	1.105	1.109	1.112	1.115	1.117	1.119
155	1.059	1.065	1.068	1.071	1.073	1.076	1.078	1.081	1.083	1.084	1.086	1.089	1.091	1.094	1.096	1.099	1.103	1.106	1.109	1.111	1.113
160	1.054	1.059	1.062	1.066	1.068	1.071	1.073	1.076	1.078	1.079	1.081	1.084	1.086	1.089	1.091	1.094	1.098	1.101	1.104	1.106	1.108
165	1.049	1.054	1.057	1.061	1.063	1.066	1.068	1.071	1.073	1.074	1.076	1.079	1.081	1.084	1.086	1.089	1.093	1.096	1.099	1.101	1.103
170	1.044	1.049	1.052	1.056	1.058	1.061	1.063	1.066	1.068	1.069	1.071	1.074	1.076	1.079	1.081	1.084	1.088	1.091	1.094	1.096	1.098
175	1.039	1.044	1.047	1.051	1.053	1.056	1.058	1.061	1.063	1.064	1.066	1.069	1.071	1.074	1.076	1.079	1.083	1.086	1.089	1.091	1.093
180	1.033	1.039	1.042	1.045	1.047	1.050	1.052	1.055	1.057	1.058	1.060	1.063	1.065	1.068	1.070	1.073	1.077	1.080	1.083	1.085	1.087
185	1.028	1.033	1.036	1.040	1.042	1.045	1.047	1.050	1.052	1.053	1.055	1.058	1.060	1.063	1.065	1.068	1.072	1.075	1.078	1.080	1.082
190	1.023	1.028	1.031	1.035	1.037	1.040	1.042	1.045	1.047	1.048	1.050	1.053	1.055	1.058	1.060	1.063	1.067	1.070	1.073	1.075	1.077
195	1.018	1.023	1.025	1.030	1.032	1.035	1.037	1.040	1.042	1.043	1.045	1.048	1.050	1.053	1.055	1.058	1.062	1.065	1.068	1.070	1.072
200	1.013	1.018	1.021	1.025	1.027	1.030	1.032	1.035	1.037	1.038	1.040	1.043	1.045	1.048	1.050	1.053	1.057	1.060	1.063	1.065	1.067
205	1.008	1.013	1.015	1.020	1.022	1.025	1.027	1.030	1.032	1.033	1.035	1.038	1.040	1.043	1.045	1.048	1.052	1.055	1.058	1.060	1.062
210	1.002	1.008	1.011	1.015	1.017	1.020	1.022	1.025	1.027	1.028	1.030	1.033	1.035	1.038	1.040	1.043	1.047	1.050	1.053	1.055	1.057
212	1.000	1.002																			

FRASER & CHALMERS

STEAM AND COAL REQUIRED

TO RAISE 100 GALLONS OF WATER 100 FEET PER MINUTE FOR 24 HOURS.

Duty in Million Foot Pounds.	Pounds Steam per 1 H. P. per hour.	Tons Coal consumed per 24 hours. Evp. 6 to 1.	Tons Coal consumed per 24 hours. Evp. 8 to 1.	Tons Coal consumed per 24 hours. Evp. 10 to 1.
10,000,000	180.	1.0	.75	.6
15,000,000	120.	.666	.5	.4
20,000,000	90.	.5	.375	.3
25,000,000	72.	.4	.3	.24
30,000,000	60.	.333	.25	.2
35,000,000	51.5	.286	.215	.171
40,000,000	45.	.25	.187	.15
45,000,000	40.	.222	.166	.133
50,000,000	36.	.2	.15	.12
55,000,000	32.8	.182	.136	.109
60,000,000	30.	.166	.125	.10
65,000,000	27.7	.154	.115	.092
70,000,000	25.7	.143	.107	.086
75,000,000	24.	.133	.1	.08
80,000,000	22.5	.125	.094	.075
85,000,000	21.2	.117	.088	.071
90,000,000	20.	.111	.083	.067
95,000,000	18.95	.105	.079	.063
100,000,000	18.	.100	.075	.06
105,000,000	17.15	.095	.071	.057
110,000,000	16.35	.091	.068	.054
115,000,000	15.65	.087	.065	.052
120,000,000	15.	.083	.062	.05
125,000,000	14.4	.08	.06	.048
130,000,000	13.85	.077	.058	.046
135,000,000	13.33	.074	.055	.044
140,000,000	12.85	.071	.053	.043
145,000,000	12.4	.069	.052	.041
150,000,000	12.	.066	.05	.04
155,000,000	11.6	.064	.048	.039
160,000,000	11.25	.062	.047	.038
165,000,000	10.9	.06	.045	.036
170,000,000	10.6	.059	.044	.035
175,000,000	10.28	.057	.043	.034
180,000,000	10.00	.055	.041	.033

The figures given above indicate the fractional part of a ton (2,000 lbs.) of coal when 100 gallons of water are raised 100 feet high every minute for 24 hours each day; 100 gallons per minute amounts to 144,000 gallons per 24 hours.

In the above, the steam horse power is assumed to be 10 per cent. greater than the theoretical water horse power; this is more than ample allowance for well-constructed pumping engines.

WEIGHT OF WATER PER CUBIC FOOT

FROM 32° TO 212° F., AND HEAT UNITS PER POUND, RECKONED ABOVE 32° F.

The following table was made by interpolating the table given by Clark as calculated from Rankine's formula, with corrections for apparent errors.

[From KENT'S MECHANICAL ENGINEER'S POCKET-BOOK.]

Temp. Deg. F.	Weight lbs. per cu. foot.	Heat Units.	Temp. Deg. F.	Weight lbs. per cu. foot.	Heat Units.	Temp. Deg. F.	Weight lbs. per cu. foot.	Heat Units.	Temp. Deg. F.	Weight lbs. per cu. foot.	Heat Units.
32	62.42	0	78	62.25	46.03	123	61.68	91.16	168	60.81	136.44
33	62.42	1	79	62.24	47.03	124	61.67	92.17	169	60.79	137.45
34	62.42	2	80	62.23	48.04	125	61.65	93.17	170	60.77	138.45
35	62.42	3	81	62.22	49.04	126	61.63	94.17	171	60.75	139.46
36	62.42	4	82	62.21	50.04	127	61.61	95.18	172	60.73	140.47
37	62.42	5	83	62.20	51.04	128	61.60	96.18	173	60.70	141.48
38	62.42	6	84	62.19	52.04	129	61.58	97.19	174	60.68	142.49
39	62.42	7	85	62.18	53.05	130	61.56	98.19	175	60.66	143.50
40	62.42	8	86	62.17	54.05	131	61.54	99.20	176	60.64	144.51
41	62.42	9	87	62.16	55.05	132	61.52	100.20	177	60.62	145.52
42	62.42	10	88	62.15	56.05	133	61.51	101.21	178	60.59	146.52
43	62.42	11	89	62.14	57.05	134	61.49	102.21	179	60.57	147.53
44	62.42	12	90	62.13	58.06	135	61.47	103.22	180	60.55	148.54
45	62.42	13	91	62.12	59.06	136	61.45	104.22	181	60.53	149.55
46	62.42	14	92	62.11	60.06	137	61.43	105.23	182	60.50	150.56
47	62.42	15	93	62.10	61.06	138	61.41	106.23	183	60.48	151.57
48	62.41	16	94	62.09	62.06	139	61.39	107.24	184	60.46	152.58
49	62.41	17	95	62.08	63.07	140	61.37	108.25	185	60.44	153.59
50	62.41	18	96	62.07	64.07	141	61.36	109.25	186	60.41	154.60
51	62.41	19	97	62.06	65.07	142	61.34	110.26	187	60.39	155.61
52	62.40	20	98	62.05	66.07	143	61.32	111.26	188	60.37	156.62
53	62.40	21.01	99	62.03	67.08	144	61.30	112.27	189	60.34	157.63
54	62.40	22.01	100	62.02	68.08	145	61.28	113.28	190	60.32	158.64
55	62.39	23.01	101	62.01	69.08	146	61.26	114.28	191	60.29	159.65
56	62.39	24.01	102	62.00	70.09	147	61.24	115.29	192	60.27	160.67
57	62.39	25.01	103	61.99	71.09	148	61.22	116.29	193	60.25	161.68
58	62.38	26.01	104	61.97	72.09	149	61.20	117.30	194	60.22	162.69
59	62.38	27.01	105	61.96	73.10	150	61.18	118.31	195	60.20	163.70
60	62.37	28.01	106	61.95	74.10	151	61.16	119.31	196	60.17	164.71
61	62.37	29.01	107	61.93	75.10	152	61.14	120.32	197	60.15	165.72
62	62.36	30.01	108	61.92	76.10	153	61.12	121.33	198	60.12	166.73
63	62.36	31.01	109	61.91	77.11	154	61.10	122.33	199	60.10	167.74
64	62.35	32.01	110	61.89	78.11	155	61.08	123.34	200	60.07	168.75
65	62.34	33.01	111	61.88	79.11	156	61.06	124.35	201	60.05	169.77
66	62.34	34.02	112	61.86	80.12	157	61.04	125.35	202	60.02	170.78
67	62.33	35.02	113	61.85	81.12	158	61.02	126.36	203	60.00	171.79
68	62.33	36.02	114	61.83	82.13	159	61.00	127.37	204	59.97	172.80
69	62.32	37.02	115	61.82	83.13	160	60.98	128.37	205	59.95	173.81
70	62.31	38.02	116	61.80	84.13	161	60.96	129.38	206	59.92	174.83
71	62.31	39.02	117	61.78	85.14	162	60.94	130.39	207	59.89	175.84
72	62.30	40.02	118	61.77	86.14	163	60.92	131.40	208	59.87	176.85
73	62.29	41.02	119	61.75	87.15	164	60.90	132.41	209	59.84	177.86
74	62.28	42.03	120	61.74	88.15	165	60.87	133.41	210	59.82	178.87
75	62.28	43.03	121	61.72	89.15	166	60.85	134.42	211	59.79	179.89
76	62.27	44.03	122	61.70	90.16	167	60.83	135.43	212	59.76	180.90
77	62.26	45.03									

TEMPERATURE OF FIRE

The following table from M. Pouillet will enable the temperature to be judged by the appearance of the fire.

APPEARANCE.	TEMP. FAH. DEGREES.	APPEARANCE.	TEMP. FAH. DEGREES.
Red, just visible	977	Orange, deep	2010
Red, dull	1290	Orange, clear	2190
Red, cherry, dull	1470	White heat	2370
Red, cherry, full	1630	White, bright	2550
Red, cherry, clear	1830	White, dazzling	2730

CONTENTS IN CUBIC FEET AND U. S. GALLONS

OF PIPES AND CYLINDERS OF VARIOUS DIAMETERS AND ONE FOOT IN LENGTH

1 gallon = 231 cubic inches. 1 cubic foot = 7.4805 gallons.

Diameter in inches.	For 1 foot in length.		Length in inches of cylinder of 1 cubic foot capacity.
	Cu. ft. also area in sq. ft.	U. S. gals. 231 cu. in.	
1/4	.0003	.0025	.....
5-16	.0005	.0040	.....
3/8	.0008	.0057	.....
7-16	.0010	.0078	.....
1/2	.0014	.0102	.....
9-16	.0017	.0129	.....
5/8	.0021	.0159	.....
11-16	.0026	.0193	.....
3/4	.0031	.0230	.....
13-16	.0036	.0269	.....
7/8	.0042	.0312	.....
15-16	.0048	.0359	.....
1	.0055	.0408	2181.81
1 1/8	.0069	.0516	1739.13
1 1/4	.0085	.0638	1411.76
1 3/8	.0103	.0770	1165.04
1 1/2	.0123	.0918	975.69
1 5/8	.0144	.1077	833.33
1 3/4	.0167	.1249	718.56
1 7/8	.0192	.1436	625.00
2	.0218	.1632	550.44
2 1/8	.0246	.1840	487.80
2 1/4	.0276	.2066	434.76
2 3/8	.0308	.2304	389.52
2 1/2	.0341	.2550	351.84
2 5/8	.0376	.2813	319.14
2 3/4	.0412	.3085	291.26
2 7/8	.0451	.3374	266.07
3	.0491	.3672	244.39
3 1/8	.0533	.3987	225.14
3 1/4	.0576	.4309	208.33
3 3/8	.0621	.4645	193.23
3 1/2	.0668	.4998	178.14
3 5/8	.0717	.5361	167.36
3 3/4	.0767	.5738	156.45
3 7/8	.0819	.6127	146.52
4	.0873	.6528	137.43
4 1/8	.0928	.6942	129.31
4 1/4	.0985	.7369	121.82
4 3/8	.1044	.7810	114.94
4 1/2	.1104	.8263	108.69
4 5/8	.1167	.8727	102.82
4 3/4	.1231	.9206	97.50
4 7/8	.1296	.9695	92.59
5	.1364	1.020	87.98
5 1/8	.1433	1.072	83.74
5 1/4	.1503	1.125	79.84
5 3/8	.1576	1.179	76.14
5 1/2	.1650	1.234	72.73
5 5/8	.1726	1.291	69.52
5 3/4	.1803	1.349	66.56
5 7/8	.1883	1.409	63.72
6	.1963	1.469	61.13
6 1/8	.2046	1.531	58.65
6 1/4	.2131	1.594	56.31
6 3/8	.2217	1.662	54.01
6 1/2	.2304	1.724	52.08
6 5/8	.2394	1.791	50.13
6 3/4	.2485	1.859	48.29
6 7/8	.2578	1.928	46.55
7	.2673	1.999	44.89
7 1/8	.2769	2.071	43.34
7 1/4	.2867	2.145	41.86
7 3/8	.2967	2.219	40.45
7 1/2	.3068	2.295	39.11
7 5/8	.3171	2.372	37.84
7 3/4	.3276	2.450	36.63
7 7/8	.3382	2.530	35.48
8	.3491	2.611	34.37
8 1/8	.3601	2.694	33.32
8 1/4	.3712	2.777	32.33
8 3/8	.3826	2.862	31.36
8 1/2	.3941	2.948	30.45
8 5/8	.4057	3.035	29.58
8 3/4	.4176	3.125	28.74
8 7/8	.4296	3.214	27.93
9	.4418	3.305	27.16
9 1/8	.4541	3.397	26.43
9 1/4	.4667	3.491	25 71
9 3/8	.4794	3 586	25.03
9 1/2	.4922	3.682	24.38
9 5/8	.5053	3.780	23.75
9 3/4	.5185	3.879	23.14
9 7/8	.5319	3.979	22.56
10	.5454	4.080	22.00
10 1/8	.5591	4.182	21.46
10 1/4	.5730	4.286	20.94
10 3/8	.5871	4.392	20 44
10 1/2	.6013	4.498	19.96
10 5/8	.6157	4.606	19.49
10 3/4	.6303	4.715	19.04
10 7/8	.6450	4.825	18.60
11	.6600	4.937	18.18
11 1/8	.6751	5.050	17.78
11 1/4	.6903	5.164	17.38
11 3/8	.7057	5.279	17.00
11 1/2	.7213	5.396	16.63
11 5/8	.7370	5.513	16.28
11 3/4	.7530	5.633	15.94
11 7/8	.7691	5.753	15 60
12	.7854	5.875	15.28
12 1/8	.8018	5.998	14.94
12 1/4	.8184	6.122	14.66
12 3/8	.8352	6.248	14.37
12 1/2	.8522	6.375	14.08
12 5/8	.8693	6.503	13.80
12 3/4	.8866	6.632	13.53
12 7/8	.9041	6.763	13.27
13	.9218	6.895	13.02
13 1/8	.9395	7.028	12.78
13 1/4	.9575	7.163	12.53
13 3/8	.9757	7.299	12.30
13 1/2	.994	7 436	12.07
13 5/8	1.013	7.578	11.85
13 3/4	1.031	7.712	11.64
13 7/8	1.051	7.855	11.42
14	1.069	7.997	11.23
14 1/8	1.088	8.139	11.03
14 1/4	1.107	8.281	10.84
14 3/8	1.127	8.431	10.65
14 1/2	1.147	8.578	10.46
14 5/8	1.167	8.730	10.28
14 3/4	1.187	8.879	10.11
14 7/8	1.207	9.029	9.94
15	1.227	9.180	9.78
15 1/8	1.248	9.336	9.62
15 1/4	1.268	9.485	9.46
15 3/8	1.289	9.642	9.31
15 1/2	1.310	9.801	9.16
15 5/8	1.332	9.964	9.01
15 3/4	1.353	10.121	8.87
15 7/8	1.374	10.278	8.73
16	1.396	10.440	8.60
16 1/4	1.440	10.772	8.33
16 1/2	1.485	11.11	8.081
16 3/4	1.530	11.45	7.843
17	1.576	11.79	7.511
17 1/4	1.623	12.14	7.394
17 1/2	1.670	12.49	7.186
17 3/4	1.718	12.85	6.985
18	1.768	13.22	6.787
18 1/4	1.817	13.59	6.604
18 1/2	1.867	13.96	6.427
18 3/4	1.917	14.34	6.259
19	1.969	14.73	6.094
19 1/4	2.021	15.12	5.938
19 1/2	2.074	15.51	5.786
19 3/4	2.128	15.92	5.639
20	2.182	16.32	5.500
20 1/4	2.237	16.73	5.365
20 1/2	2.292	17.15	5.236
20 3/4	2.348	17.56	5.110
21	2.405	17.99	4.989
21 1/4	2.463	18.42	4.872
21 1/2	2.521	18.86	4.760
21 3/4	2.580	19.30	4.651
22	2.640	19.75	4.545
22 1/4	2.700	20.20	4.445
22 1/2	2.761	20.66	4.347
22 3/4	2.823	21.12	4.251
23	2.885	21.58	4.160
23 1/4	2.948	22.05	4.070
23 1/2	3.012	22.53	3.990
23 3/4	3.076	23.01	3.901
24	3.142	23.50	3.819
25	3.409	25.50	3.520
26	3.678	27.58	3.263
27	3.976	29.74	3.018
28	4.276	31.99	2.806
29	4.587	34.31	2.616
30	4.909	36.72	2.444
31	5.241	39.21	2.290
32	5.585	41.78	2.149
33	5.940	44.43	2.020
34	6.305	47.16	1.903
35	6.681	49.98	1.796
36	7.069	52.88	1.698
37	7.467	55.86	1.607
38	7.876	58.92	1.527
39	8.296	62.06	1.446
40	8.727	65.28	1.375
41	9.168	68.58	1.309
42	9.621	71.91	1.247
43	10.085	75.44	1.190
44	10.559	78.99	1.136
45	11.045	82.62	1.087
46	11.541	86.33	1.040
47	12.048	90.13	.996
48	12.566	94.00	.955
49	13.095	97.96	.916
50	13.635	102.00	.880
51	14.186	106.12	.846
52	14.748	110.32	.814
53	15.320	114.60	.783
54	15.904	118.97	.755
55	16.499	122.82	.727
56	17.104	127.95	.702
57	17.720	132.55	.677
58	18.347	137.24	.654
59	18.985	142.02	.632
60	19.637	146.89	.611

To find the capacity of pipes greater than the largest given in the table, look in the table for a pipe one-half the given size and multiply its capacity by 4, or one of one-third its size, and multiply its capacity by 9, etc.

TABLE SHOWING THE MEAN EFFECTIVE PRESSURE

IN CYLINDER OF NON-CONDENSING CORLISS ENGINES WHEN CUTTING OFF AT

Boiler Pressure above atmosphere in lbs. per sq. in.	1/10	1/9	1/8	1/7	1/6	1/5	1/4	3/10	1/3	4/10	1/2	Economical M. E. P.
30		1	2	4	5	8	11	14	15	18	21	21
35	1	2	4	6	8	11	14	17	18	22	25	23
40	3	4	7	8	10	13	17	20	22	26	30	25
45	5	6	9	11	13	16	20	24	26	30	34	26
50	7	8	11	13	16	19	23	27	29	34	38	28
55	9	10	13	16	18	22	26	31	33	38	42	29
60	11	12	15	18	21	24	30	34	36	41	47	30
65	13	14	17	20	23	27	33	38	40	45	51	32
70	14	16	20	23	26	30	36	41	44	49	55	33
75	16	18	22	25	28	33	39	44	47	53	60	34
80	18	20	24	27	31	35	42	48	51	57	64	35
85	20	22	26	30	33	38	45	51	54	61	68	36
90	22	24	28	32	36	41	48	55	58	65	72	37
95	24	26	30	34	38	44	51	58	61	69	77	38
100	26	28	33	37	41	46	54	61	65	73	81	39

It will be noticed when referring to the column at right of table that for 80 pounds steam pressure, a cut-off at 1-5 stroke shows the most economical results; while at 90 pounds pressure an earlier cut-off can be employed with the best economy.

The pressures stated are approximate, owing to the omission of decimals.

MEASURES OF WORK, POWER AND DUTY

HORSE POWER.

The rate of work. Unit of horse power = 33,000 ft.—pounds per minute, or 550 ft.—lbs. per second = 1,980,000 ft.—lbs. per hour.

HEAT UNIT.

Heat required to raise 1 lb. of water 1° F. (from 39° to 40°).

Horse power expressed in heat units = $\frac{33000}{778}$ = 42,416 heat units per minute = .707 heat unit per second = 2,545 heat units per hour.

1 lb. of fuel per horse power per hour = $\frac{\text{1,980,000 ft.—lbs. per lb. of fuel.}}{\text{2,545 heat units per lb. of fuel.}}$

1,000,000 ft.—lbs. per lb. of fuel = 1.98 lbs. of fuel per horse power per hour.

BAROMETRIC READINGS

CORRESPONDING ALTITUDES, AND ATMOSPHERIC PRESSURE PER SQUARE INCH.

Barometer in Inches.	Approximate Altitude in Feet.	Pressure per Square Inch.	Barometer in Inches.	Approximate Altitude in Feet.	Pressure per Square Inch.
20.0	11,250	9.82	25.6	4,400	12.56
20.1	11,110	9.87	25.7	4,290	12.61
20.2	10,970	9.91	25.8	4,180	12.66
20.3	10,840	9.96	25.9	4 070	12.71
20.4	10,700	10.01	26.0	3,970	12.76
20.5	10,560	10.06	26.1	3.860	12.81
20 6	10,430	10.11	26.2	3,750	12.86
20.7	10,290	10.16	26.3	3,650	12.91
20.8	10,160	10.21	26.4	3,540	12.96
20.9	10,030	10.26	26.5	3,440	13.01
21.0	9,900	10.31	26.6	3,330	13.06
21.1	9,760	10.36	26.7	3.230	13.10
21.2	9,630	10.40	26.8	3,130	13.15
21.3	9,500	10.45	26.9	3,020	13.20
21.4	9,370	10.50	27.0	2,920	13.25
21.5	9,240	10.55	27.1	2,820	13.30
21.6	9,110	10.60	27.2	2,710	13.35
21.7	8,990	10.65	27.3	2,610	13.40
21.8	8,860	10.70	27.4	2,510	13.45
21.9	8,730	10.74	27.5	2,410	13.50
22.0	8,600	10.80	27.6	2,310	13.55
22.1	8,480	10.85	27.7	2,210	13.60
22.2	8,350	10.90	27.8	2,110	13.64
22.3	8,230	10.94	27.9	2,010	13.69
22.4	8,100	10.99	28.0	1,910	13.74
22.5	7,980	11.04	28 1	1,810	13.79
22.6	7,860	11.09	28.2	1,710	13.84
22.7	7,730	11.14	28.3	1,610	13.89
22.8	7,610	11.19	28.4	1,520	13.94
22.9	7,490	11.24	28.5	1,420	13.99
23.0	7,370	11.29	28.6	1,320	14.04
23.1	7,250	11 34	28.7	1,220	14.09
23.2	7,130	11.39	28.8	1,130	14.14
23.3	7,010	11.44	28.9	1,030	14.18
23.4	6,890	11.48	29.0	940	14.23
23.5	6,770	11.53	29.1	840	14.28
23.6	6,660	11.58	29.2	750	14.33
23.7	6,540	11.63	29.3	650	14.38
23.8	6,420	11.68	29.4	560	14.43
23.9	6,300	11.73	29.5	460	14.48
24 0	6,190	11.78	29.6	370	14.53
24.1	6,070	11.83	29.7	270	14.58
24.2	5,960	11.88	29.8	180	14.63
24.3	5.840	11.93	29.9	90	14.67
24.4	5,730	11.98	30.0	0,000	14.72
24.5	5,620	12.02	30.1	90	14.77
24.6	5,500	12.07	30.2	180	14.82
24.7	5,390	12.12	30.3	270	14.87
24.8	5,280	12.17	30.4	360	14.92
24.9	5,170	12.22	30.5	450	14.97
25.0	5,060	12.27	30.6	550	15.02
25.1	4,940	12.32	30.7	640	15.07
25.2	4,830	12.37	30.8	730	15.12
25.3	4,720	12.42	30.9	820	15.17
25.4	4,620	12.47	31.0	910	15.21
25.5	4,510	12.52			

Barometer in inches multiplied by .4908—pressure per square inch.

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FRASER & CHALMERS'

SEDERHOLM BOILER

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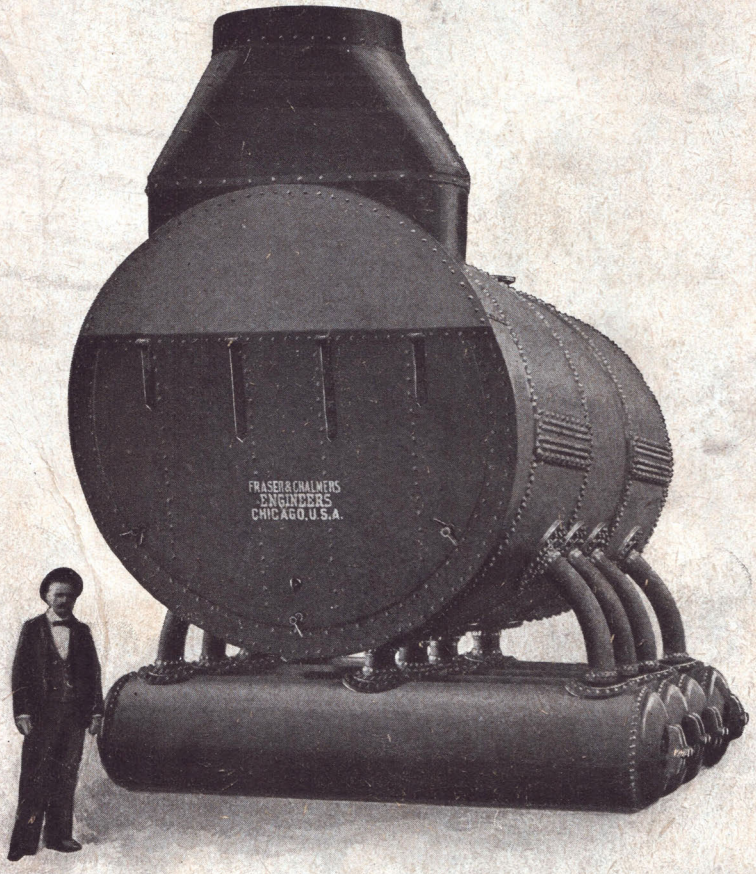

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